Role of Geospatial technology in Crime Mapping: a perspective view of India

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ABSTRACT

The advancement in computer science technology and development of GIS application softwares and the accessibility of various geographic data through open source data sources make it feasible for police and law enforcement departments to use it effectively. Crime mapping and spatial analysis using GIS tools such as hot spot generation, zonation, navigation, and crime profiling, mobile location identification and web based various application are well recognized and can be scientifically applied for betterment of citizens whereas it can be effectively used for prediction and control of crime. The present study analyzed the temporal crime data (Murder, dacoity, robbery, burglary, theft and riots) of India from the year 2001 to 2015 to understand the temporal trend whereas state wise crime data (IPC crime registered) from the year 2011 to 2015 was utilized to generate crime density map and percent change. We have also used the crime data for 10 cities (highest crime rate) of India including all metro cities for the year 2015 to understand city crime trend towards various crimes types. By analyzing the crime data of 2015 the study reveals that the crime density was in the range of 65.8 to 1140 the lowest in Nagaland whereas highest in Delhi which was found to be roughly 4.5 times than the national average. After the evaluation of crime percent change for the year 2015 with preceding year it was found that 29.6% largest increase in crime in Daman and Diu whereas Kerala and Delhi got second and third position with value 24.3% and 23% respectively. The evaluation of ten cities including the metro cities was done for the year 2015. The various city crime (total cognizable crime under IPC) per lakh population varies from 189.4 to 925.9 was found highest in the city Indore whereas it was found lowest in Chennai city. Murder, dacoity, robbery, burglary, theft, riots and other IPC crime per lakh population were found in the range of (0.9 to 11.3), (0 to 1.7), (0.6 to 31.1), (1.1 to 57.17), (14.8 to 445.6), (0.5 to 35.4) and (147.7 to 576.2) respectively. Patna city leads in Murder...
and dacoity. Indore leads in the crime like burglary and other IPC crime. Delhi city reported highest in robbery, theft whereas record was found lowest in riots.

**Keywords**: Crime Analysis, Geographical Information Systems, Crime Mapping, India

1. **INTRODUCTION**

Crime is a human phenomenon which violates the existing law of any country punishable under various existing countries laws. In India it is punishable under various section of *Indian Penal Code* (IPC) in India. In developing and less developed countries such as third world the crime data is still organized manually in the form of hardcopies. Although in India, apart from various important cities the crime maps are mostly not available in the context of crime locations, police station jurisdiction areas, administrative boundaries etc in GIS domain or in digital form. This limits the scope of better monitoring because crime analysis such as hot spotting, zonation, navigation facilities, criminal profiling, landuse patterns, terrain conditions etc. cannot be analyzed and assessed. Crime mapping and spatial analysis using GIS tools are well recognized for the study and control of crime. This is the most powerful information technology required in law enforcement. GIS has been widely used by law enforcement agencies for better policing in developed countries. It is in developing stage in India. Although the police forces have started using GIS technology but it is limited to the metro cities for developing a (spatial) system by examining patterns of crime and for predicting the future criminal events and their probable locations gives a huge boost as operational and tactical aspects is the major concern.

In India GIS technology is in budding stage. It is not adequately recognized in crime mapping and analysis therefore it is not considered as an mandatory tool within the police force, whereas National Crime Records Bureau, Ministry of Home Affairs started GIS utilities even though due to lack of GIS experts.

2. **WHY GEO-INFORMATICS IN CRIME MAPPING?**

The advancement in information technology, software and hardware has become boon to utilize this for specific purposes. Remote sensing data, GIS and GPS can be potentially used to harness in variety of applications in crime. The tools in GIS efficiently capture, store, manipulate, update, visualize all forms of geographically reference material (https://www.igi-global.com/dictionary/gis/12192). The data queries (simple and complex) and data analysis such as hotspot generation, understanding the spatial, temporal trend and its pattern analysis can be used in crime mapping process. GPS data of crime can be utilized for updating/identifying various crime and its activities spatially. The high resolution remote sensing data can be successfully utilized for delineating urban area building, roads parks, shopping malls, police station and various features which are useful for crime mapping especially in cities. The simple example of one of the data clock of crime only retain date and time which was used for temporal hotspot mapping by Richard Weiss is given in the Figure 1.
This study simply reveals the most of the crime taken place in the month of November and December whereas robbery is roughly a night time phenomenon whereas burglary is day time phenomenon.

The spatial relationship between crime location and other factors such as demography including education level, housing (pakkah, kachha and jhuggis) and socio-economic conditions including employment status and laborer class people can give better understanding of the place and crime and its relationship based on the compared parameters (Alves et al 2013; Anderson and Anderson 1984; Lawrence and Cohen 1979; Cotte Poveda 2012; Cusimano et al 2010; Hojman 2002; Hojman 2004; Kelly 2000; Levitt 2001).

Figure 1. Data clock of crime provide temporal hotspot analysis

The prediction of crime occurrences has gained large attention because of its prospective benefits and utility. (Alves et al. 2013; Gerber 2014; Gorr et al. 2003; Liao et al. 2010; Mohler et al. 2011; Wang et al. 2010).

Location is the one the most important aspects in crime (Brantingham and Brantingham 1991). The place of crime and any other information geographic information involved with criminal incident gives lot of information about the nature of crime and its characteristics. This help in better design of prevention, assessment and analysis of criminal incidence. The spatial relationship of crime with respect to the education level was studied by Weisburd and McEwen (1997). He found inverse connection between the education levels of the resident population and regions of violent crime. A mobile phone location identification in a cellular network based on the signal strength & angle of radio waves with a cell phone has become boon for crime prediction and identification. (http://www.electroschematics.com/5231/mobile-phone-how-it-works/)

Although GIS has been adequately used in India in various applications such as urban mapping (Ahmad and Goparaju 2016), forest change mapping (Ahmad and Goparaju 2017b), agroforestry mapping (Ahmad et al. 2017; Ahmad and Goparaju 2017a ) etc. whereas crime mapping is still devoid of its utility effectively in the field of crime.

The crime mapping/analysis is widely used in developed country such as in Canada (Eikelboom et al. 2017), in USA (Jefferson 2017; Bunting et al. 2017) and in New Zealand (Curtis-Ham and Walton, 2017) but very few research has been done in the field of crime mapping especially in developing country. Khalid et al. 2017 evaluated and generated hotspot mapping of crime in Faisalabad, Pakistan. The study reveals that street crimes are strongly concentrated in the central part of the city whereas, the results manifest that the functional nature of different urban land use affects the frequency of crime events. They finally concluded that the hotspot analysis has real potential, impacting the police patrolling protocols.

Wang et al. 2013 studied the crime mapping with real world dataset from a northeastern city in the United States. Comparison studies with the Hot Spot Analysis tool executed by Esri ArcMap 10.1 validates that HOT is capable of accurately mapping crime hotspots. Malvika (2015) did the crime mapping of Rajasthan, India at district level. The study reveals the application of GIS and graphical tool as well as some important statistics in crime mapping is the need of the hour and should be given preference over the traditional crime recording methods. Karuppannan et al. 2004 studied the crime of Chennai city of India in GIS domain. The study showed that, GIS is a much more robust and compatible tool of crime pattern analysis than the current processes because of its geographic referencing capabilities.

In India the GIS mapping/analysis/queries/hotspot generation in crime evaluation is almost nil therefore it is considered as a potential research gap which can be highly useful for the policy makers if the outcome will be suitably interpolated in time for the betterment of the citizens and for the law enforcement agencies.

The present study aims to applying state wise crime data from the year 2011 to the year 2015 for India and generation of crime map in GIS domain year wise and understanding the temporal trend of crime, state wise. It is also recorded percent wise and depicted in the form of map. The trend of crime for 10 major cities of India was also evaluated.
3. STUDY AREA

The study area was taken as the whole country including 4 union territories includes Delhi, Chandigarh, Pondicherry and Daman and Diu. The study area falls between roughly 8° 29' 40" N to 36° 54' 28" N latitude and 68° 14' 45" E to 97° 28' 30" E longitude. India occupies 10th rank (1.76 million crimes) in the world as far as the world crime ranking is concerned which is equivalent to roughly 15% of the crime of USA (http://www.nationmaster.com/country-info/stats/Crime/Total-crimes). India retains land equivalent of 2.41% of the world's land area but supports over 18% of the world's population. Based on 2001 census of India 72.2% of the population lives in villages whereas remaining 27.8% lived in towns. Based on 2011 census data of India Delhi city has the highest population density equivalent to 9340, whereas as far as the states are concerned Bihar has the highest 1102.

4. MATERIAL AND METHODS

The vector file for the country and various states was downloaded from DIVA GIS website (http://www.diva-gis.org/Data). Various state wise crime data (IPC crime registered) from the year 2011 to 2015 was downloaded from National Crime Records Bureau, Ministry of Home Affairs, India. We have also downloaded the India wise crime data of the country (Murder, dacoity, robbery, burglary, theft and riots) from the year 2001 to 2015 to understand the temporal trend. We have also downloaded the crime data for 10 cities (highest crime rate) of India including all metro cities for the year 2015 to understand city trend towards various crimes types. The analysis was done in ARC/ GIS Software/ MS EXCEL. Six columns in polygon vector in attribute for the year 2015, 2014, 2013, 2012, 2011 and for population 2011 were created. The state wise crime number and population were filled in each respected column. India census data is only available at 10 years interval. We have used Indian census data 2011 (latest) to understand crime density of each state in each year. In our study crime density from the year 2011 to 2015 were also evaluated based on same population data available of the year 2011. Based on data we have also created crime map showing temporal crime density as well as state wise percent change in crime (decrease and increase) when compared with the crime data to preceding year. Telangana state was created in the year 2014 and data was only available for the year 2015 and 2014.

5. RESULT AND DISCUSSION

Temporal trend of various crimes in India

The country wise crime in India is given in figure-2 and figure-3. Murder crime was more in the year 2001 and shows a decreasing trend from the year 2001 to 2009 whereas it shows increasing trend from 2009 to 2012. Dacoity crime was more in the year 2001 and 2002 but further shows a decreasing temporal trend whereas in the year 2015 it is sharply reduced. Robbery was noted to be roughly within the control from the year 2001 to 2006, it also showing the constant increasing trend from 2006 onwards whereas a sharp increase was observed from 2010 to 2014. Riots were highest in the year 2001 and 2012, whereas the
burglary was reported highest in the year 2014 and 2015. Theft was recorded lowest in the year 2002 whereas it showing constantly increasing trend till the year 2015.

**Figure 2.** Crime (Murder, Dacoity and Robbery) in India in lakh from 2001-2015

**Figure 3.** Crime (burglary, theft, riots) in India in lakh from 2001-2015
State wise temporal trend of crime (IPC crime registered) in India

The crime map generated for the year 2015, 2014, 2013, 2012 and 2011 were given in figure from figure-4a, figure-4c, figure-4e, figure-4g and figure-4i respectively whereas crime percent increase and decrease for the year 2015, 2014, 2013 and 2012 with preceding year is given in figure-4b, figure-4d, figure-4f and figure-4h respectively. The crime density values state wise for the year 2015 varies from 65.8 to 1140 the lowest in the state of Nagaland whereas highest in Delhi whereas national average was 243.6. The second highest is Kerala which retains the value 769.5 was found roughly 3 times with national average value. After evaluation of crime percent change for the year 2015 it was found 29.6% largest increase in crime in Daman and Diu when compared with preceding year whereas Kerala and Delhi got second and third position with value 24.3% and 23% respectively. In the same year largest decrease in crime was observed in Goa with value 31.2% followed by Sikkim with value 28.1%. Similarly crime density values state wise for the year 2014 varies from 58.5 to 927.2, once again the lowest in the state of Nagaland whereas highest in the Delhi whereas national average was 235.5. The second highest is Kerala which retain the value 619. After evaluation of crime percent change for the year 2014 it was found 94.3% largest increase in crime in Delhi when compared with preceding year whereas Mizoram got second position with value
25.2%. In the same year largest decrease in crime was observed in Chandigarh with value 21.0 % followed by Gujarat with value 16.5%.

Crime density values state wise for the year 2013 varies from 61.5 to 527.9, once again the lowest in the state of Nagaland whereas highest in the Kerala whereas national average was 218.7. The second highest is Delhi which retain the value 477.6. After evaluation of crime percent change for the year 2013 it was found 61.2% largest increase in crime in Sikkim when compared with preceding year whereas Delhi got second position with value 47.7%. In the same year largest decrease in crime was observed in Manipur with value 15.0 % followed by Pondicherry with value 12.3%. Crime density values state wise for the year 2012 varies from 55.1 to 475.9, once again the lowest in the state of Nagaland whereas highest in the Kerala whereas national average was 197.2. The second highest is Pondicherry which retain the value 343.1. After evaluation of crime percent change for the year 2012 it was found 16.4% increase in crime in Assam when compared with preceding year whereas Manipur got second position with value 16.1%. In the same year largest decrease in crime was observed in Himachal Pradesh with value 12.3 % followed by Sikkim with value 11.4%.

Crime density values state wise for the year 2011 varies from 54.7 to 515.3, once again the lowest in the state of Nagaland whereas highest in the Kerala whereas national average was 192.1. The second highest is Pondicherry which retain the value 349.5.

6. CITY CRIME EVALUATION

![City crime of India 2015 per lakh of 10 city](image)

*Figure 5. City crime 2015 (Murder, dacoity, robbery, burglary, theft, riots and other IPC crime)*
Ten cities including the metro city was evaluated for the year 2015 based on higher crime data types are given in the figure-5. The various city crime per lakh population varies from 189.4 to 925.9 was found highest in the city Indore whereas was found lowest in Chennai as per total cognizable crime under IPC is concern. Murder crime varies among the cities were in the range of 0.9 to 11.3 per lakh population was found highest in Patna whereas found lowest in Mumbai. Dacoity as a crime per lakh population was 0 in Jaipur to highest 1.7 in Patna. The crime such as robbery per lakh population was least in Kolkata (0.6) whereas it was highest (31.1) in the city of Delhi. Burglary, theft, riots and other IPC crime per lakh population were found with the range of (1.1 to 57.17), (14.8 to 445.6), (0.5 to 35.4) and (147.7 to 576.2) respectively. Indore leads in the crime like burglary and other IPC crime. Delhi was found highest in theft whereas found lowest in riots.

7. CONCLUSIONS

Remote sensing, GIS and GPS are highly useful add-on technology in crime mapping and crime prediction and identification. Historical crime data and its location when analyzed with other thematic data sets such as location of police station, road network, shopping malls, buildings, recreational centre with urban sprawl and girls school and colleges, mobile police van location and installed camera location etc manifest several clues which can be highly useful for crime identification and prevention. The Unique Identification Number (UID) and its linking with mobile SIM in India are going on will further boost to reduce the crime. The data of various hotspot of crime can be utilized to install cameras/ establishing the new police station/ and mobilizing the police patrolling in these locations.

Crime rate and its nature varies from state to state and from city to city and its cause mostly related to social, economic, mental abnormality, geographical and political (http://lawnn.com/crime/). The Kerala state overall represents the highest cognizable crime rate whereas in union territory Delhi is on top of the list.

The state of Kerala shows better policing as well as the people are more aware as a result, most of the crime incidents get reported. In contrary, most of the other states of India, police themselves refuses to register the crimes so as to keep the crime rate low. Delhi shows a huge gap between the rich and the poor. About one-third of the city population lives in slums which mostly consist of migrated people from the other states in search of job retain poor socioeconomic condition with high illiteracy rates. They live in inhuman conditions devoid of any basic amenities. Therefore due to unemployment, poverty and illiteracy crime flourishes. Also, people have become habituated with crime because of the slow judicial process, they develops a feeling that he/she can easily get away with after committing a crime.

Based on the report of the national newspaper Time of India (TOI, 2016) A retired supreme court judge Justice Markandey Katju blames poverty as the main cause of crime. He also quoted “Unless you create a social and political order in which everybody gets a decent life, which means proper employment, proper incomes, healthcare, education and nutritious food for the children, you cannot abolish crime.” Our study reveals crime in Nagaland is low and showing the continuous decreasing trend every year. The leading Indian newspaper “The Hindu” quoted the statement of Neingulo Krome, secretary general Naga People Movement for Human Rights, told “Ours is a very peaceful society. There are negligible cases of crime
within society and if we come across anyone with criminal instincts, the person is usually ostracised from the society,” Singh (2016)

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References


